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June 1978

Research and Development

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Pollution Effects of Abnormal Operations in Iron and Steel Making - Volume III. Blast Furnace Ironmaking, Manual of Practice

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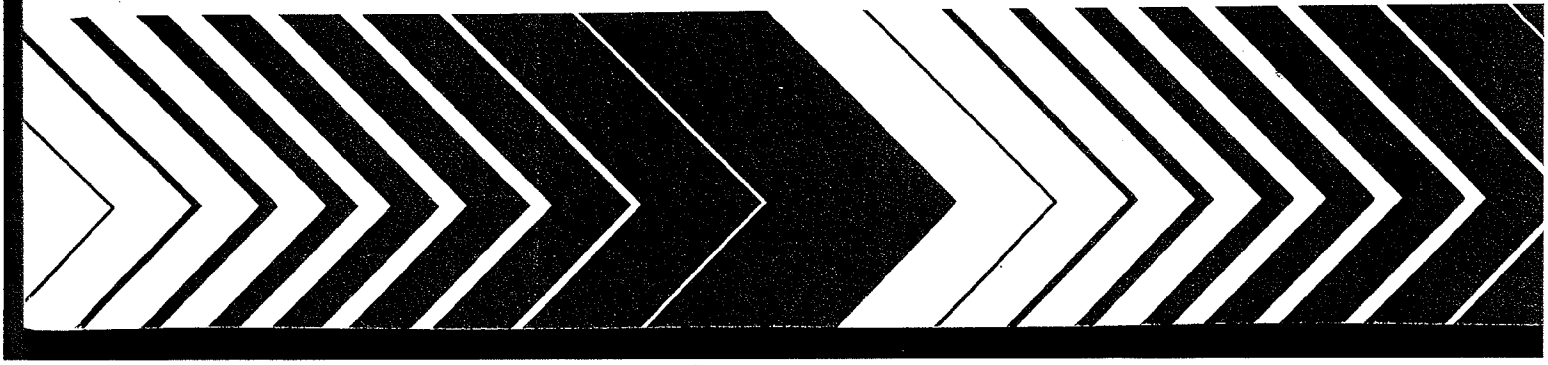

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Pollution Effects of Abnormal Operations in Iron and Steel Making - Volume III. Blast Furnace Ironmaking, Manual of Practice

by

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PREFACE

This study of the environmental effects of substandard, breakdown, or abnormal operation of steelmaking processes and their controls has been made to provide needed perspective concerning these factors and their relevance to attainment of pollution control. The use of the term Abnormal Operating Condition (AOC) herein, in characterizing any specific condition should not be construed to mean that any operator is not responsible under the Clean Air Act as amended for designing the systems to account for potential occurrence in order to comply with applicable State Implementation Plans or New Source Performance Standards.

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INTERNATIONAL SYSTEM OF UNITS AND ALTERNATIVE (METRIC) UNITS
WITH CONVERSION FACTORS

Quantity	SI Unit/Modified SI Unit	Equivalent To
mass	kg	2.205 lb
	Mg (megagram = 10^6 grams)	2205 lb
	Mg	1.1025 ton
	Gg (gigagram = 10^9 grams)	
volume	m^3 (cubic meter)	35.32 cf
	dscm (dry standard cubic meter)	
	scm (standard cubic meter: 21°C, 1 atm)	
	ℓ (liter = 0.001 m^3)	
concentration or rate	g/m^3 (grams/m^3)	0.437 gr/ft^3
	mg/m^3 (milligrams/m^3)	0.000437 gr/ft^3
	g/kg	2 lb/ton
energy	J (joule)	0.000948 Btu
	kJ/m^3 (kilojoules/m^3)	0.02684 Btu/ft^3
	MJ (megajoules = 10^6 joules)	
	MJ/Mg	0.430 Btu/lb
		859 Btu/ton
force	kPa (kiloPascal)	0.146 lb/in^2
	1 Pascal = 1 N/m^2 (Newton/m^2)	
area	m^2 (square meter)	10.76 ft^2

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

Air and water pollution standards, generally based upon control of discharges during normal (steady-state) operation of a control system, are frequently exceeded during "upsets" in operation. When such upsets become repetitive and frequent, the regional and local enforcement agencies undertake, through consent agreements, to work with the plant toward resolution of the problem, and plans are developed for such equipment and operating practice changes as will eliminate or alleviate the frequent violations. Should the planning process fail to resolve abnormally frequent occurrences of malfunctions, the problem may lead to litigation. Thus, periods of abnormal operation are becoming recognized as possibly contributing to the emissions of high concentrations of pollutants. Similarly, upsets may contribute to spills of increased amounts of effluent-borne pollutants into waterways.

There is a need for information concerning abnormal operating conditions (AOC): their identity, cause, resulting discharges, prevention, and minimization.

The purpose of the manual is to alert those who deal with environmental problems on a day-to-day basis to the potential problem areas caused by abnormal conditions, to assist in determining the extent of the problem created by abnormal conditions in a specific plant, and to provide help in evaluating any efforts to reduce or eliminate the problems. The processes considered are those in the primary section of the integrated iron and steel plant. Included are the sintering, blast furnace ironmaking, open hearth, electric arc furnace, and basic oxygen steelmaking. This manual covers the blast furnace ironmaking process.

This manual is based on reviews of somewhat limited data, visits to a few of the many steel plants, interviews with persons intimately involved in either steelmaking or attendant environmental regulations, and the expertise of the study team. It is, therefore, a preliminary assessment which concentrates on enumerating as many of the conditions as possible, with emphasis on those which have the most severe environmental impact.

Each process is described separately. Descriptions include flow diagrams and material balances, operating procedures and conditions. The flow sheets and material balances presented are representative of the most typical process configurations.

Within each process are variations, both in the process itself and in the equipment for control of pollution. Variations in equipment and process are accompanied by variations in AOC. It is, therefore, of value to identify as many of the variations as possible. At the same time, it is necessary to limit consideration of the numerous alternatives to those which are currently in greatest application and use.

1.2 DEFINITION OF AOC

In general, an abnormal operating condition (AOC) is considered to be that which departs from normal, characteristic or steady-state operation, and results in increased emissions or discharges. In addition to abnormal operations, this study includes the startup and shutdown difficulties of processes and control equipment. It also includes substantial variations in operating practice and process variables, and outages for maintenance, either scheduled or unscheduled.

The use of the term Abnormal Operating Condition (AOC) in characterizing any specific condition should not be construed to mean that any operator is not responsible under the Clean Air Act as amended for designing the systems to account for potential occurrence in order to comply with applicable State Implementation Plans or New Source Performance Standards.

2.0 DISCUSSION OF THE BLAST FURNACE IRONMAKING PROCESS, NORMAL OPERATION

The blast furnace converts iron oxide to molten iron. A typical burden (feed) comprises ore, sinter, limestone, and coke. The coke provides thermal energy for the process. The limestone becomes calcined, melts, reacts with and partially removes sulfur from the molten iron.

The burden material is charged into the top of the furnace and descends slowly. Heated air is injected through tuyeres near the bottom of the furnace. The air moves countercurrent to the burden, consuming the coke carbon thereby providing energy for the process. Blast furnace gas leaves through offtakes at the top of the furnace, is cleaned of particulates and used as a byproduct fuel. Molten iron and slag are tapped periodically from the bottom of the furnace.

2.1 PROCESS FLOW SHEET

A flow sheet for the blast furnace ironmaking process is shown in Figure 1.

Burden material is charged through a device which allows the entry of lump material and restricts the outward flow of blast furnace gas. Blast furnaces are generally over 100 feet tall and may be 30 feet or more in hearth diameter. The blast furnace, Figure 2, is roughly pear-shaped, with the hot metal and slag formed at the hearth. The furnace uses more air than any other raw material, by weight. Thermal economy demands that this air be preheated before it is injected into the hearth through a series of tuyeres (nozzles). The air consumes coke to provide heat for the process. Coke also is consumed by reaction with the iron oxide, reducing it to molten iron.

Blast furnace gas, which is mostly carbon monoxide (1/3) and nitrogen (2/3), leaves the top of the furnace through offtakes. The flow of gas through the burden entrains dust. The dust is removed by a dust catcher (which is a low efficiency cyclone) and a high energy wet scrubber. A gas cooler lowers the temperature of the gas, thereby condensing most of its water vapor and making it suitable for use as fuel.

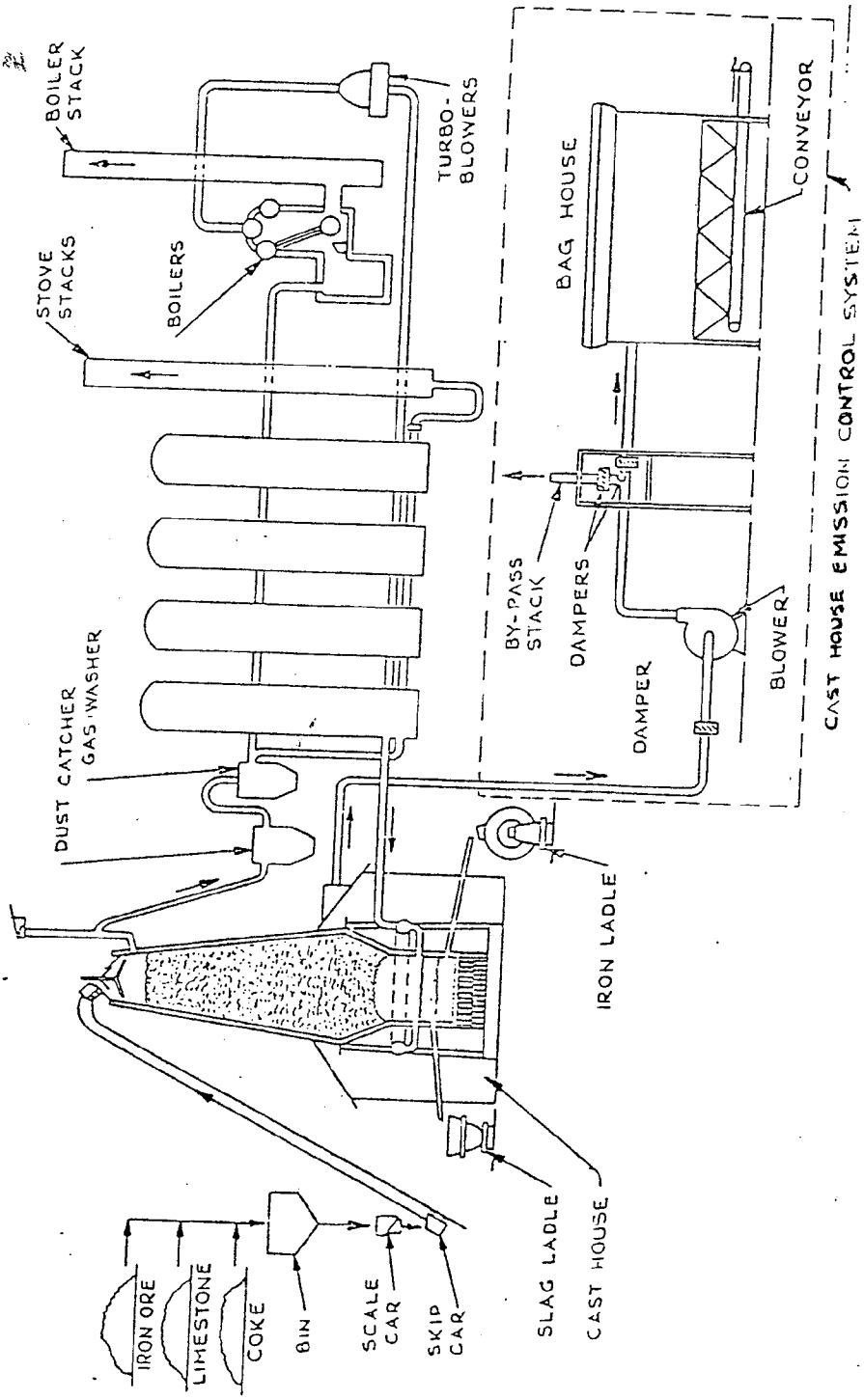

Figure 1. Blast furnace plant with auxiliary equipment.

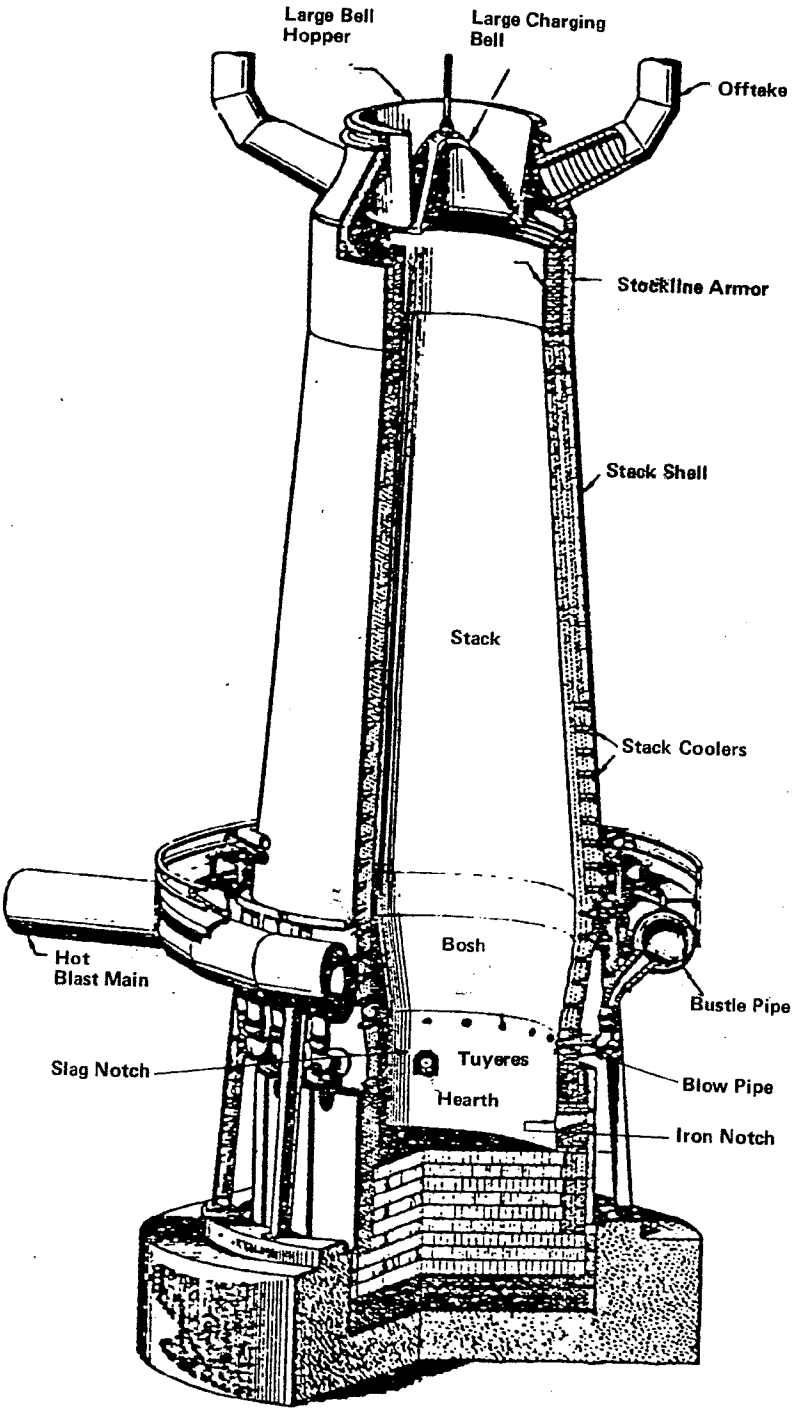

Figure 2. Blast furnace.